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**Proceedings of the Pacific regional peer review meeting on an Assessment Protocol for
Commercial Harvest of Pacific Oysters (*Crassostrea gigas*) in British Columbia**

**December 4, 2012
Nanaimo, British Columbia**

Chairperson and Editor: Nicholas Duprey

Fisheries and Oceans Canada
Science Branch
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

These Proceedings summarize the relevant discussions and key conclusions that resulted from a Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) Regional Peer Review meeting on December 4, 2012 at the Pacific Biological Station in Nanaimo, BC. DFO has recently taken over responsibility for the management of the wild Pacific Oyster (*Crassostrea gigas*) fishery in BC from the BC Ministry of Agriculture (BC MoA). A Research Document evaluating the assessment and management frameworks used by the BC MoA for the wild oyster fishery in BC and the proposed assessment protocol for use by DFO were presented for peer review.

In-person participation included DFO Science, Fisheries and Aquaculture Management (FAM), and Fish Protection (DFO) staff as well as invited representatives from the Province of BC, First Nations, the commercial and recreational fishing sectors, and academia.

The conclusions and advice resulting from this review will be provided in the form of a Research Document and a Science Advisory Report providing advice to Science and FAM on the protocols to be used in assessing wild Pacific Oyster stock in BC.

The Research Document and supporting Science Advisory Report will be made publicly available on the Canadian Science Advisory Secretariat (CSAS), Fisheries and Oceans Canada Website.

Compte rendu de la réunion régionale d'examen Protocole d'évaluation pour la récolte commerciale d'huîtres sauvages (*Crassostrea gigas*) en Colombie-Britannique

SOMMAIRE

Le présent compte rendu résume les discussions pertinentes et les principales conclusions de la réunion régionale d'examen par des pairs du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada (MPO), qui a eu lieu le 4 décembre 2012 à la station biologique du Pacifique de Nanaimo, en C.-B. Le MPO a récemment repris du ministère de l'Agriculture de la C.-B. (BC MoA) les responsabilités de gestion de la pêche aux huîtres sauvages du Pacifique (*Crassostrea gigas*) dans cette province. On a présenté aux fins d'examen par les pairs, un document qui analyse l'évaluation et la gestion des cadres qui ont servi au BC MoA pour la pêche aux huîtres sauvages et un protocole d'évaluation proposé que le MPO doit utiliser.

La réunion en personne comptait des représentants du secteur des sciences, de Gestion des pêches et de l'aquaculture (GPA) et du Programme de protection des pêches du MPO, ainsi que des représentants invités de la Province de la C.-B., des Premières Nations, des secteurs des pêches commerciales et récréatives et du milieu universitaire.

Les conclusions et les conseils qui découlent de l'examen en question seront publiés sous forme de document de recherche et dans un Avis scientifique qui doivent offrir des conseils au secteur des sciences et à GPA au sujet des protocoles qui doivent servir à évaluer les stocks d'huîtres sauvages du Pacifique en C.-B.

Le document de recherche et l'Avis scientifique connexe seront disponibles au public dans le Site Web du Secrétariat canadien de consultation scientifique (SCCS) de Pêches et Océans Canada

INTRODUCTION

A Fisheries and Oceans Canada (DFO) Canadian Science Advisory Secretariat (CSAS) Regional Peer Review (RPR) meeting was held on December 4, 2012 at the Pacific Biological Station in Nanaimo to review a method for providing advice to Fisheries Managers on Total Allowable Catch (TAC) for the wild Pacific Oyster (*Crassostrea gigas*) commercial fishery in BC.

The Terms of Reference (TOR) for the science advice (Appendix C) were developed in response to a request for advice from Fisheries and Aquaculture Management (FAM) branch. Notifications of the science review and conditions for participation were sent to various representatives with relevant expertise in the subject area, including internal (DFO Science, FAM, and Fish Protection) and external (Provincial government, First Nations, commercial and recreational fishing sectors, and academia) representatives.

The following working paper was prepared and made available to meeting participants prior to the meeting:

Assessment Protocol for the Commercial Harvest of Pacific Oysters (*Crassostrea gigas*) in British Columbia. Norgard, T., Gillespie, G. and Bigg, M. CSAP Working Paper 2012/P34.

The meeting Chair, Nicholas Duprey, welcomed participants, reviewed the role of CSAS in the provision of peer-reviewed advice, and gave a general overview of the CSAS process. The Chair discussed the role of participants, the purpose of the various RPR publications [Science Advisory Report (SAR), Proceedings, and Research Document], and the definition and process around achieving consensus decisions and advice. Everyone was invited to participate fully in the discussion and to contribute knowledge to the process, with the goal of delivering scientifically defensible conclusions and advice. It was confirmed with participants that all had received copies of the TOR, draft working paper, and draft SAR.

The Chair reviewed the Agenda (Appendix A) and the TOR (Appendix C) for the meeting, highlighting the objectives and identifying the Rapporteur (Dan Leus). The Chair then reviewed the ground rules and process for exchange, reminding participants that the meeting was a science review and not a consultation.

Members were reminded that everyone at the meeting had equal standing as participants and that they were expected to contribute to the review process if they had information or questions relevant to the paper being discussed. In total, 21 people participated in the RPR (Appendix B).

Participants were informed that Brian Kingzett (Centre for Shellfish Research, Vancouver Island University) and Steve Schut (DFO FAM) had been asked before the meeting to provide detailed written reviews for the working paper to assist everyone attending the peer-review meeting. Participants were provided with copies of the written reviews.

The conclusions and advice resulting from this review will be provided in the form of a Research Document and a SAR providing advice to FAM on the harvest rate and stock assessment protocol for the wild Pacific Oyster fishery in BC.

The Research Document and supporting SAR will be made publicly available on the CSAS Science Advisory Schedule at Canadian Science Advisory Secretariat (CSAS), Fisheries and Oceans Canada Website.

REVIEW

Working Paper:

Assessment Protocol for the Commercial Harvest of Pacific Oysters (*Crassostrea gigas*) in British Columbia. Norgard, T., Gillespie, G. and Bigg, M. CSAP Working Paper 2012/P34

Rapporteur: Dan Leus

Presenter: Tammy Norgard

PRESENTATION OF WORKING PAPER

Tammy Norgard gave a presentation that closely followed the major topics from the working paper, the abstract of which is included in Appendix D. Key points and additional information includes:

- a temperature of 20°C for 20 days is required for gonad development and spawning
- it was clarified that much of the harvested product is used as seed for aquaculture tenures
- the nested quadrat experiment was conducted in two locations near Nanaimo, BC
- a single Pacific Oyster weighs about 0.2 kg and thus 0.2 kg was used to select the appropriate number of quadrats in re-sampling analyses
- the authors preferred the presented, defensible, random survey design; any attempt at using a set survey design would likely be influenced by biases.

POINTS FOR CLARIFICATION

After the presentation, the Subcommittee had some points for clarification which the authors addressed.

Historically the province conducted pre- and post-harvesting stock assessment surveys. The pre-survey occurred in the spring before harvesting had begun for the year. The post-season survey occurred in the fall after the fishery had taken place.

There were some changes to the tables and diagrams presented in the presentation and those found in the paper distributed to meeting attendees. This was due to a few small errors found by the authors after the paper was submitted to CSAS. The corrections were made and the diagrams and tables presented in the meeting are the correct versions which will be presented in the final version of the paper. These changes also include a change from density to biomass for population estimates.

It was re-iterated that the maximum age of oysters reported in the literature is 10-40 yrs.

WRITTEN REVIEWS AND SUBCOMMITTEE DISCUSSIONS

In advance of the meeting, written reviews were solicited from two individuals who are knowledgeable in the area: Brian Kingzett (Centre for Shellfish Research, Vancouver Island University) and Steve Schut (DFO FAM). Both reviewers felt the paper was well written and their full reviews are given in Appendix E.

One of the reviewers thought the paper was straight forward, not a complex analysis, and had few comments regarding the assessment procedure. This reviewer also commented that the procedures have been used before and are acceptable. The second reviewer had previously worked for the province of BC (who used to be responsible for Pacific Oyster assessments) and he focused his review on the history of management and less on the science methods

presented in the paper. A brief synopsis of the topics discussed by the reviewers, authors, and Subcommittee members follows.

Several additions to the Introduction of the working paper were discussed in regards to improving the context of the fishery and previous provincial assessments. Some of these suggested additions included: (1) explaining that, historically, surveys were designed to be affordable, only collecting the minimal amount of data needed to manage the fishery; (2) explaining that there was a lack of regulation or policy to structure a requirement for a survey protocol, which resulted in a poor recording or accounting of what happened in the field; and (3) detailing the logistics (methods, containers/tools used) and economics of the fishery. Also, while complaints of over-harvesting were noted in the working paper, the Subcommittee was not aware of any known historical incidents of over-harvesting of Pacific Oyster in British Columbia.

It was highlighted that the current assessment methods only focus on large aggregations of the population and not the entire population. Animals that are not in the large delineated beds will not be part of the surveyed population. It is therefore important to note that the assessed population is an under-estimate of the total population. In the future, when harvest rates are being considered, this should be taken into account. Also the paper needs to clarify that this species' distribution is highly patchy, with some areas having large high-density clusters and others having many small clusters distributed over large areas. However, the Subcommittee recognizes that this survey protocol is a start and will be used mostly on large, high-density clusters. It may be necessary in the future to develop a different protocol for other types of distributions.

The Subcommittee would like to see more discussion on the number of quadrats needed for each stratum. The paper recommends 10 quadrats be sampled for every 2000 m², but does not elaborate on why this number was chosen or on how very small strata would be treated. The Subcommittee would like the authors to re-assess their statistics and more clearly state the required number of quadrats that are needed for surveyed strata. The revised paper should include in the discussion and recommendations how many quadrats should be used on areas of different strata size. Together with this discussion the Subcommittee asked for clarification on how Pacific Oyster bed size was calculated and the estimated costs and times for surveying different quadrat sizes. The Subcommittee accepts the quadrat size recommended in the paper. However, the Subcommittee would like to see more discussion on why the larger quadrats are more efficient in cost/time per square meter surveyed. For example, the authors indicated that the 75x75 cm quadrat took approximately 6 times longer to survey than the 25x25 cm quadrat, but the former had a surface area 9 times larger than the latter. Why is this? The section discussing the differences in variance between the four different quadrat sizes also needs more discussion and clarification. Some Subcommittee members expected the use of smaller quadrats, covering the same surveyed surface area, to yield smaller variance (greater precision) and would like to see some more wording about this added to the paper.

It was satisfactorily explained to the Subcommittee, during the meeting, how quadrats were nested and how the strata areas were measured but the authors need to strengthen the description in the paper to clarify these methods. The authors wished to make a further clarification in regards to bed size; although delineation of a Pacific Oyster bed may be a polygon, the surveyed area is rectangular and it is this rectangular area that is used in assessments.

The methods on how the statistical power of the sample sizes was calculated needs better explanation in the text of the paper. There was some confusion on how the different tests of statistical power were conducted and what the final conclusions from the authors were about those tests.

The reasoning behind using the value of 0.2 kg in the precision calculations is not clearly described in the paper. The Subcommittee asked for more clarification in the paper about why this 0.2 kg value was used and how this differs from the 30% value used in the other precision calculations.

In addition, there was discussion around the increased edge effect that smaller quadrat sizes incur and whether a correction factor could be calculated to correct for these effects. The authors argued that a correction factor may be heavily influenced by a non-standardized surveyor and thus would not be advised. The presented experimental design addresses the real-world application of the edge effect, by using nested quadrats rather than simulations, and makes recommendations based on these real data. The authors agreed to clarify the wording in regards to the variances seen between different quadrat sizes, the recommendations on which size is best suited for the survey would remain the same.

Adding biological sampling to the survey protocol was discussed with some commenting this would allow information on meat quality to be collected during the surveys. There was a feeling from an industry representative that meat quality is better in individual oysters at the periphery of beds. While there was a desire to collect more samples to increase the dataset on various biological parameters, these biological samples were not recommended by the authors so as to avoid burdening industry surveyors with too many requirements. Including biological sampling could be looked at for future protocols, but currently they are seen as too costly to conduct.

The authors noted that two local Nanaimo area beaches (which are not fished commercially) were used as test sites for the methods presented in the paper. While the Subcommittee understands the reasons these areas were used (logistics, budgetary limitations, staff access, etc.) these reasons should also be clearly stated in the paper, with a discussion about how appropriate these beaches are compared to highly-active commercial Pacific Oyster beaches. The authors did state that this protocol would be an iterative process that would change as more experience is developed from surveying other commercial beaches.

The Subcommittee would like to see a more thorough discussion of weight versus abundance. This topic is mentioned briefly in the text of the working paper but needs to be clarified and fully rationalized. The merit of using different metrics in the assessment was also discussed, specifically using weight versus density. The authors felt that biomass was the better metric for assessment purposes, but agreed more wording was needed on what biomass is in terms of 'harvestable product'. There are also complications inherent with either metric choice as Pacific Oyster harvesters target a large range of sizes for a variety of purposes (seeding tenures, direct to market, etc.). Changing and fine tuning the protocol for differing needs in the future is possible, but this protocol was designed to get a starting point to address an immediate need for this year's fishery.

There was much discussion on the harvest rate section of the paper. The presented review of different harvest models and potential parameters for those models are an excellent starting point for further work on providing advice for Pacific Oyster harvest rates in British Columbia. However, the Subcommittee felt it would be too early to use the presented information to establish recommended harvest rates. More work is required in this area before any recommended harvest rates for the Pacific Oyster population could be made. It was recommended that the harvest section remain in the paper as a starting point for future harvest rate work and it should be noted that the Subcommittee discussion included some major faults with some of the models and therefore no preference should be indicated in the paper. The authors agreed to add clarification on the limitations of the Hoenig equation and the limited conclusions that can be derived from the presented information.

One reviewer felt that the growth rates of oysters from aquaculture sites would indicate wild stock age structure is around a 6-yr old age class. Discussion focused around what the actual maximum age for oysters is in the wild. While aquaculture may provide some information about age and mortality, it is also restrictive as age and mortality of animals on aquaculture sites may not be fully informative as they are not likely to fully achieve their maximum age. As for the appropriate age for use in the harvest models, the Subcommittee agreed that the maximum published age for oysters would be a good starting place until more data can be collected.

The committee also wanted to see the paper be more clear about the scale at which the assessment protocol should be defined from. Are the authors suggesting these methods for assessing a meta-population as a beach or as a population on a coast-wide scale as is assumed in the models.

One reviewer mentioned a possible conflict with the Olympia Oyster (*Ostrea lurida*) as a possible bycatch during commercial harvest. This issue was not mentioned in the working paper and will not be added to the paper. These possible interactions will be mentioned in the SAR as an ecosystem consideration. The focus of the working paper is only on presented methodology.

CONCLUSIONS

Based on the paper, the presentation, the reviews, and the proceeding discussions, the Subcommittee concluded that the presented paper provides appropriate recommended assessment protocols for Pacific Oysters; the paper is accepted conditional upon the following revisions:

- The assessment protocol should be more clearly defined in terms of scale (assess a meta-population as a beach or as a population on a coast-wide scale as is assumed in the models).
- More clarity on how statistical power was calculated in the paper.
- More clarity on when weight is the metric and when abundance is the metric and why one is being chosen over the other.
- Improve the description of how oyster bed size is calculated.
- Add a discussion on the limitations of using two non-commercial sites for this analysis and an evaluation and how this analysis can be extrapolated to other beds.
- Add a specific sampling requirement (see recommendation 3). Authors indicated they would revisit this recommendation to provide a more detailed recommendation on the number of quadrats required to be surveyed for varying bed sizes.
- Further elaborate in paper why the larger quadrats are more efficient in cost/time per square meter surveyed.
- Authors agreed to make changes to the Recommendations as per the following comments:

Recommendation 1: "Simple random sampling survey methods should be used."

Subcommittee Conclusion #1

- Adopt Recommendation 1 with the removal of the word 'Simple' from "Simple Random Sampling" and the addition of the word "Stratified" (should then read "Stratified Random Sampling").
- Further elaborate in the paper on how strata are identified.

Recommendation 2: "A quadrat size of no less than 75x75 cm is required."

Subcommittee Conclusion #2

- Adopt Recommendation 2 as it stands.

Recommendation 3: "Sampling intensity should be ≥ 10 samples per 2000 m² area."

Subcommittee Conclusion #3

- Would like to see a more specific sampling requirement.

Recommendation 4: "A range of harvest rates between 3-14% are appropriate for this species."

Subcommittee Conclusion #4

- Remove this recommendation, but leave the content as a 'conclusion' with discussion for future required work

ACKNOWLEDGEMENTS

Brian Kingzett (Centre for Shellfish Research, Vancouver Island University) and Steve Schut (DFO FAM) each provided a thorough written review of the working paper. Their efforts in providing this feedback to the committee and authors are greatly appreciated. Also the committee greatly appreciated Dan Leus acting as rapporteur for the meeting.

APPENDIX A - AGENDA

Regional Advisory Process (RAP)

Centre for Science Advice Pacific

AGENDA

Assessment Protocol for the Commercial Harvest of Pacific Oysters (*Crassostrea gigas*) in British Columbia

December 4, 2012

PBS Seminar Room, Taylor Building, Rooms 227A&B
Pacific Biological Station
3190 Hammond Bay Road, Nanaimo, British Columbia V9T 6N7

Chairperson: Nick Duprey

9:00	Welcome & Introductions	Nick Duprey
9:15	Review Agenda & Housekeeping	Nick Duprey
9:30	Review of Terms of Reference	Nick Duprey
9:45	Presentation of Working Paper	Tammy Norgard
10:30	<i>Break</i>	
10:45	Reviewer Presentation & Author Response	Brian Kingzett
11:30	Reviewer Presentation & Author Response	Steve Schut
12:15	<i>Lunch Break</i>	
1:15	Group Discussion to Identify Issues and Topics Needing Further Discussion on Working Paper	RAP Participants
3:15	<i>Break</i>	
3:30	Group Discussion to Identify Issues and Topics Needing Further Discussion on Science Advisory Report	RAP Participants
4:30	<i>Adjournment</i>	

APPENDIX B - PARTICIPANT LIST

Last Name	First Name	Affiliation
Bigg	Michelle	DFO, FPP
Bureau	Dominique	DFO, Science
Clark	Dan	DFO, FAM
Duprey	Nick	DFO, Science
Gillespie	Graham	DFO, Science
Hajas	Wayne	DFO, Science
Hand	Claudia	DFO, Science
Leus	Dan	DFO, Science
Marcus	Kerry	DFO, FAM
Nguyen	Hai	DFO, Science
Norgard	Tammy	DFO, Science
Parker	Guy	DFO, FAM
Pearce	Chris	DFO, Science
Perry	Ian	DFO, Science
Schut	Steve	DFO, AMD
Zhang	Zane	DFO, Science
External Participants		
Crowley	Sabrina	Nuu-chah-nulth Tribal Council
Dudas	Sarah	Vancouver Island University
Kingzett	Brian	Vancouver Island University
Yakimishyn	Jennifer	Parks Canada
Vautier	Kevin	Commercial Harvester

APPENDIX C - TERMS OF REFERENCE

TERMS OF REFERENCE

Assessment Protocol for Commercial Harvest of Pacific Oysters (*Crassostrea gigas*) in British Columbia

Regional Peer Review Meeting- Pacific Region

December 4, 2012

Nanaimo, British Columbia

Chairperson: Nicholas Duprey

Context

Since 1912, the wild oyster (*Crassostrea gigas*) fishery has been managed by the Province of British Columbia (BC). As a result of the Hinkson court decision in February 2009 the responsibility for the management of the wild oyster fishery was transferred from the province of BC to the Department of Fisheries and Oceans (DFO) in January 2012. Future fishing opportunities will be dependent upon the development of assessment protocols capable of providing estimates of stock status, thus allowing DFO to establish sustainable science-based quotas. These protocols will be used by industry or contracted third parties to conduct surveys, collect data, and complete data analyses.

Objectives

The objective of the Research Document and Science Advisory Report is to develop new stock assessment protocols and methodologies for assessing wild oyster populations.

The following working paper will be reviewed to provide the basis for discussion and advice:

Assessment Protocol for the Commercial Harvest of Pacific Oysters (*Crassostrea gigas*) in British Columbia. Norgard, T., Gillespie, G. and Bigg, M. CSAP Working Paper 2012/P34

Expected publications

- CSAS Research Document (1)
- CSAS Science Advisory Report (1)
- CSAS Proceedings (1)

Participation

- DFO Science
- DFO Fisheries Management
- DFO Aquaculture Management
- DFO Fish Protection
- Province of BC
- Commercial and recreational fishing interests
- First Nations
- Academia

APPENDIX D - ABSTRACT FROM WORKING PAPER

The following is the abstract, as submitted for review, from:

Assessment Protocol for the Commercial Harvest of Pacific Oysters (*Crassostrea gigas*) in British Columbia. Norgard, T., Gillespie, G. and Bigg, M. CSAP Working Paper 2012/P34

This document evaluates the assessment and management frameworks utilized by the BC Ministry of Agriculture (BC MoA) for the wild oyster harvest and proposes a Pacific Oyster assessment protocol for use by the Fisheries and Oceans Canada (DFO) and Industry as DFO assumes responsibility for management and regulation of the fishery.

Pacific Oysters were brought to BC in 1912 or 1913 and have been cultured and harvested since. Successful reproductive events in the 1940s, 1950s and 1960s resulted in the establishment of Pacific Oyster throughout the Strait of Georgia. Subsequent transplants resulted in the establishment of wild populations in suitable habitats on the west coast of Vancouver Island. Establishment of wild populations led to development of a commercial fishery in the 1940s that continues to the present. The Provincial government was responsible for management of this commercial fishery until 2012, when a legal decision resulted in responsibility shifting to Fisheries and Oceans Canada.

This study documents Provincial management and stock assessment frameworks and recommends a statistically-based survey protocol for Pacific Oysters that recommends optimal quadrat size ($75 \times 75\text{cm} = 0.5625\text{ cm}^2$) and minimum sampling intensity of 10 quadrats per 2000 m^2 .

This study used a range of estimated mortality rates in Pacific Oysters, which were subsequently used in surplus production models to propose defensible harvest rates (3-14% of the estimated biomass) for fishery managers.

APPENDIX E - WRITTEN REVIEWS

REVIEWER 1

Reviewer Comments

Assessment Protocol for the Commercial Harvest of Pacific Oysters (*Crassostrea gigas*) in British Columbia. Norgard, T., Gillespie, G. and Bigg, M. CSAP Working Paper 2012/P34

Pacific Regional Advisory Process

Reviewer: Brian Kingzett, Centre for Shellfish Research, Vancouver Island University, Nanaimo
Working Paper

*Assessment Protocol for the Commercial Harvest of Pacific Oysters (*Crassostrea gigas*) in British Columbia. Norgard, T., Gillespie, G. and Bigg, M. CSAP Working Paper 2012/P34.*

Thank-you for the opportunity to comment on this paper, I believe it presents a sound analysis protocol to most effectively and efficiently assess wild oyster beds, with possible application methodology to aquaculture stock assessment. Beyond a few minor editorial comments, the majority of my comments relate to the process of setting harvest rates for this specific fishery which may beyond the scope of this project.

Is the purpose of the working paper clearly stated?

Yes – purpose of the paper is laid out in the introduction – I would consider moving the fourth paragraph to the beginning of the introduction and put the subject of the paper up front.

Are the data and methods adequate to support the conclusions?

The experimental protocol and the calculations that have led to determining the optimum survey method is well laid out and I do not have any significant comments on the methodology or approach.

Are the data and methods explained in sufficient detail to properly evaluate the conclusions?

For the assessment goals as stated yes

If the document presents advice to decision-makers, are the recommendations provided in a useable form, and does the advice reflect the uncertainty in the data, analysis or process?

Yes I believe so – most comments on the approach are philosophical relating to the unique management of this species and are listed below

Can you suggest additional areas of research that are needed to improve our assessment abilities?

The use of harvest rates (Page 22) are valid for a wild stock where fishing rates act significantly upon potential broodstock and broodstock rates can be tied to recruitment. This fishery is unique in that it is:

1. Operating on an introduced exotic species that is not generally considered to have conservation goals or producing critical habitat for coexisting species that would encourage the preservation of oyster beds.
2. No size or age limit is set on the fishery, and as stated in the introduction, some harvesters may be participating in the fishery for market size oysters, others may be collecting stock for reseeding or a combination thereof

-
3. Given the 3-4 week larval period wild spawning parent stocks are often located away from harvest area (i.e., Pipestem Inlet shellfish reserve area outside of Barkley Sound harvest areas).
 4. In many cases parent populations are spawning stocks from aquaculture operations not subject to wild fishery pressure. Given that Larval recruitment cannot necessarily be tied to the specific beds that are subject to wild harvest, setting harvest rates based on individual bed size may not have any effect on future recruitment. The harvest rate principles discussed are all presumably based on traditional fishery management principles that harvest stock biomass is related to the recruitment ability of the total stock. I note that there are a limited number of harvest sites that are available for this fishery, the wider abundance the species in general beyond discrete beds, and the fact that most parent stocks may be much larger populations related to aquaculture stocks.

Given the above factors, it is important for the authors to justify why setting individual bed harvest rates should be at volumes/percentages typically used for total population estimates. For example If the rational is regulatory (DFO policy), maintaining levels of stock for recreational fishers or so that individual beds can maintain a certain volume that can be harvested on an annual basis through individual growth.

Similarly I noted some confusion as to whether targets are for individuals or bed biomass. If harvest programs and quota are being set by tonnage and there are no size limits in the fishery it is much more valuable to simply produce an estimate of biomass (not population) and use this to set harvest rates within the same season. Calculating population numbers and recruitment rate may not be required to set a harvest rate when bed to bed assessment irrespective of total stock abundance is being used. Historically this has been a low value opportunistic fishery that existed when market conditions and stocks on specific beaches were robust enough for prospective fishers to make application for harvest and in many cases whole beds would be removed on annual basis especially when seed was being targeted. Given the low value, low entrance and other unique aspects of the fishery I believe that the authors should comment on the justification for the population assessment protocol and its application. I believe that this will strengthen the protocol for when it is presented for industry consultation.

Misc General Comments:

- Page 4 – Para 1. If true I believe it would be useful to indicate that the 1912 agreement was for Native Oysters *Ostrea Lurida* not the Pacific Oyster which became established later.
- Page 5 Para 3 – typo “should be have been tested”
- Page 5 Para 4 – on gravel banks at the tidal mouths of small streams
- Page 11 – Para 2 – provide locational lat long for study sites
- Page 19 – Para 2 – typo Should not Shouldk
- Is the use of winter mortality rates due to the fact that surveys are conducted in summer/fall and then applications are made after the winter? Anecdotally winter mortality is low in BC unless there is physical disturbance and most intertidal mortality in aquaculture in the Pacific Northwest is summer mortality.
- The authors should consider whether the coexistence of native Olympia oysters should be evaluated in the protocol. As this is a species of concern and “by-catch” of this species may be a risk, more conservative management on specific beds may be required.

REVIEWER 2

Canadian Science Advisory Secretariat, Pacific Region

Regional Advisory Process Reviewers Comments

Reviewer: Steven Schut, Aquaculture Management Division, Pacific Region

Working Paper:

Assessment Protocol for the Commercial Harvest of Pacific Oysters (*Crassostrea gigas*) in British Columbia. Norgard, T., Gillespie, G. and Bigg, M. CSAP Working Paper 2012/P34

Reviewer Comments

Introduction

Overall the purpose of the working paper is clearly stated, and the writing and ideas are clearly articulated. However, the paper could benefit from some additional detail in the introduction would provide context to the feasibility of recommendations for decision makers.

A brief discussion of the demographics of typical wild oyster harvesters would be useful:

- What education level?
- Where are they located?
- Is this their sole source of income?
- Paper requires a clearer discussion of logistics of wild harvesting:
- How do they access the beach? Where?
- What kinds of tools and containers do they use?
- How many harvesters for how long?
- What kind of stock do they target (densities, sizes, tidal height)?

Paper requires a clearer more thorough discussion of patchy spatial distribution of oyster beds and reefs.

- How large are typical strata?
- How many strata can be found on a typical beach?
- What are typical densities of strata vs. non-strata?

A fuller treatment of rationale for the provincial methodology would highlight some of the challenges with management of the fishery:

- Use of daylight tides is preferable both for the assessment of the beaches, to allow good measurements and for the harvest to allow for monitoring and enforcement of the harvest conditions. The best daylight tides begin in late March and continue through August.
- Beaches fronting FN Reserves were set aside for allocation to FN interests only.
- Not sure if there were ever any allegations of overharvest leveled at the province, mostly because of a lack of public interest. However, there was never any evidence of wide scale decline of the population either, which is probably one of the main reasons that the province did not spend more time developing management protocols for the fishery.

Two notes on Oyster habits of relevance:

- Tidal height of oyster populations seems to vary among geographic regions, they seem to be at lower tidal heights on the west coast for instance.

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- The percentage of shell weight in an oyster sample is extremely variable and is dependent not only on the age of the oysters but also on growth pattern. So weight may be a poor surrogate measure for anything. (And of course this doesn't even speak to the presence/absence of epiphyte/epifauna, particularly barnacle sets)

The mapping methodology of the Provincial management system is not very clear.

- The outline of the stratum was delineated using GPS and processed using GIS to estimate the area of the stratum.
- The area of each individual strata was multiplied by the density estimate for that strata to get tonnage and then all the tonnages on the beach were added together to get the total tonnage of "harvestable" stock on the beach.
- Stock outside these strata was not considered harvestable and so was not incorporated into the estimate.

Methods

To be honest I have not evaluated your statistical methodology, however I do have some questions about the physical beach sampling methodologies which were not so clear to me. Sorry if some of the questions are silly, but sometimes it was not clear to me.

I am unclear what criteria you used to determine what constituted a strata and more importantly how you then determined how to lay a grid on it?

If a beach had 20 different oyster patches on it of varying sizes and large spaces in between, would you lay a stratum on each patch, or groups of patches, or contiguous strata to cover the entire beach?

Can you explain how you physically took 4 different nested quadrat measures at the same location?

From what I read it seems you took a total of 80 unique physical quadrat samples from a single stratum at Neck Point and 40 unique physical quadrat samples from two strata at Shack Island

- 80m² of 1125m² at Neck Point is a fair percentage of area sampled, did the quadrats ever overlap?
- Is 120 samples enough?

Can you provide a brief explanation why the negative binomial distribution is a suitable model for oysters?

Have you considered that two oyster beaches in the near vicinity of Nanaimo may not be representative of the beaches where oyster fishing actually occurs?

How did you arrive at the conclusion that strata size has an impact on precision?

The discussion of biological sampling should probably include a paragraph on the relationship between weight and abundance.

The estimate of less than 25% mortality rate in BC is based on the assumption that mortality is exclusively temperature dependent?

A final comment, generally the relationship between weight and abundance has not been well enough highlighted. This could have a fundamental impact on harvest rate calculations etc. It may not be a solvable problem, but I feel it needs to be better addressed as a source of error.

I hope my comments are helpful and look forward to discussing them.